

PROCRASTINATION BY PIGEONS: PREFERENCE FOR
LARGER, MORE DELAYED WORK REQUIREMENTS

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In three experiments, pigeons chose between alternatives that required the completion of a small ratio schedule early in the trial or a larger ratio schedule later in the trial. Completion of the ratio requirement did not lead to an immediate reinforcer, but simply allowed the events of the trial to continue. In Experiment 1, the ratio requirements interrupted periods in which food was delivered on a variable-time schedule. In Experiments 2 and 3, each ratio requirement was preceded and followed by a delay, and only one reinforcer was delivered, at the end of each trial. Two of the experiments used an adjusting-ratio procedure in which the ratio requirement was increased and decreased over trials so as to estimate an indifference point—a ratio size at which the two alternatives were chosen about equally often. These experiments found clear evidence for “procrastination”—the choice of a larger but more delayed response requirement. In some cases, subjects chose the more delayed ratio schedule even when it was larger than the more immediate alternative by a factor of four or more. The results suggest that as the delay to the start of a ratio requirement is increased, it has progressively less effect on choice behavior, in much the same way that delaying a positive reinforcer reduces its effect on choice.

Key words: choice, ratio schedules, delay, procrastination, key peck, pigeons

A typical dictionary defines *procrastination* as “putting off habitually and reprehensibly the doing of something that should be done.” In everyday examples, what makes procrastination reprehensible is that postponing a task frequently leads to a larger task, a greater expense, or a more serious problem later on. Thus, when people postpone a visit to the dentist, a small repair job on the house or car, or the reading assignments for a college course, later they often face painful dental work, a larger and more costly repair job, or an all-night cramming session followed by a poor grade.

Each of these situations involves a choice between a small, fairly immediate aversive event and a larger, more delayed aversive event. These choices are therefore symmetrical but opposite to self-control choices, which are sometimes defined as choices between small, fairly immediate reinforcers and larger, more delayed reinforcers (e.g., Ainslie, 1975; Logue, 1988; Rachlin & Green, 1972). The main differences between these

two types of choices are (a) that one involves two reinforcers and the other two aversive events, and (b) that maximizing long-term benefits involves a choice of the more delayed reinforcer but the less delayed aversive event. That is, the total amount of reinforcement is maximized by choosing the larger, more delayed reinforcer, but the aversive stimulus is minimized by choosing the more immediate, but smaller, aversive event.

Several studies on choice with delayed aversive events have obtained results that are analogous to those obtained with positive reinforcers. For example, Deluty (1978) found that rats would choose a large, delayed punisher over a smaller, more immediate punisher. In addition, as the delays to both punishers were increased by equal amounts, the rats showed preference reversals similar to those found in parallel situations with delayed positive reinforcers. Deluty, Whitehouse, Mellitz, and Himeline (1983) found that if rats had the opportunity to make a choice in advance, they would often make a response that committed them to receiving a smaller, more immediate shock over a larger, more delayed shock. This behavior is similar to what has been found in self-control situations when subjects had the chance to make an early commitment to the larger, more delayed reinforcer (Ainslie, 1974; Rachlin & Green, 1972). Himeline (1970) found that rats would

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make a response that postponed a shock even though the total number of shocks was not reduced. All of these results suggest that the effect of delay is similar for reinforcers and aversive stimuli: As the delay between a choice response and the reinforcer or aversive stimulus increases, that stimulus has less effect on choice behavior. There have also been studies on self-control in which the long and short delays were replaced with large and small response requirements (e.g., Eisenberger & Adornetto, 1986; Eisenberger, Weier, Masterson, & Theis, 1989; Grossbard & Mazur, 1986). To my knowledge, however, there have been no studies using self-control procedures in which the large and small delayed events were themselves different response requirements.

The present set of experiments was conducted to determine whether delayed response requirements have effects on choice behavior that are symmetrical but opposite to those of delayed reinforcers. In these studies, pigeons chose between two ratio requirements that differed in their sizes and in the delay between a choice response and the onset of the ratio schedule. For both alternatives, completion of the ratio requirement did not lead to an immediate food reinforcer, but it simply allowed the events of the trial to continue. The main question in this research was whether pigeons would choose a larger ratio schedule over a smaller one if there was a longer delay to the onset of the larger ratio schedule. A related question was whether preference for the larger ratio schedule would increase systematically as its delay increased.

In two of the three experiments presented here, an adjusting-ratio schedule was used to measure choice (cf. Grossbard & Mazur, 1986; Mazur, 1986; Mazur & Kralik, 1990). In this procedure, subjects chose between a *standard alternative*, which included a fixed-ratio (FR) response requirement, and an *adjusting alternative*, which included an adjusting-ratio response requirement. The number of responses required by the adjusting ratio was systematically increased and decreased several times a session (based on a subject's choices) so as to estimate an indifference point—a ratio at which the two alternatives were chosen about equally often. For example, in one condition, the standard alterna-

tive included an FR 5 response requirement that began 2 s after a choice response was made. For the adjusting alternative, the response requirement began 12 s after a choice response was made. If the mean adjusting ratio at the indifference point was 20 responses, this would indicate that a five-response requirement delayed 2 s was about equally preferred to a 20-response requirement delayed 12 s. This would also constitute an example of procrastination—the choice of a more delayed response requirement even though it required more work.

One concern in conducting this research was whether the requirement of completing a ratio schedule consisting of key-peck responses would constitute an aversive event for pigeons. A study by Neuringer and Schneider (1968) found that varying the number of key-peck responses per reinforcer had little effect on pigeons' behavior as long as the total time between reinforcers remained the same. This might mean that key pecking was no more aversive than the simple passage of time. However, other studies suggest that key pecking is at least slightly more aversive for pigeons than simple delays with no response requirements. Using adjusting-ratio choice procedures, Mazur (1986) and Grossbard and Mazur (1986) found that pigeons would choose fixed-time (FT) schedules over FR schedules that had the same average times between a choice response and reinforcement. Another relevant finding is Appel's (1963) observation that pigeons would escape from stimuli associated with a large ratio schedule. These results indicate that, at least under certain conditions, the presence of a ratio requirement can serve as an aversive event for pigeons. There may be differences between response requirements and aversive events such as shock (cf. Eisenberger, 1992), but for the present purposes, their similarities will be emphasized.

To increase the likelihood that the ratio schedules used in Experiment 1 would function as aversive events, a variable-time (VT) schedule of reinforcement was in effect for most of each trial (i.e., both before and after the ratio requirement). The presence of the ratio requirement therefore interrupted periods in which food was delivered at varying intervals. For the standard alternative, an FR 5 schedule had to be completed each trial,

and the time between a choice response and the onset of the FR schedule was either 2 s or 6 s (in different conditions). For the adjusting alternative, the size of the ratio was adjusted over trials to estimate an indifference point, and the time between a choice response and the onset of the ratio requirement was varied across conditions. Experiment 1 showed that the procrastination effect could be obtained under these conditions, but there were at least two possible explanations of the effect: Subjects may have been avoiding a more proximal ratio requirement, or they may have been avoiding a more proximal timeout from positive reinforcement (because the VT schedules were suspended while subjects completed the ratio requirements). To distinguish between these possibilities, the VT schedules were replaced with delay periods in Experiments 2 and 3, and only one reinforcer was delivered, at the end of each trial. As in Experiment 1, the delay between a choice response and the onset of the ratio schedule was varied across conditions to see if subjects would choose progressively larger ratio requirements as these delays increased.

EXPERIMENT 1

Method

Subjects. Four White Carneau pigeons were maintained at about 80% of their free-feeding weights. All had previous experience with a variety of experimental procedures.

Apparatus. The experimental chamber was 30 cm long, 30 cm wide, and 33 cm high. Three response keys, each 1.8 cm in diameter, were mounted in the front wall of the chamber, 20.5 cm above the floor. A force of approximately 0.15 N was required to operate each key, and each effective response produced a feedback click. Each key could be transilluminated with lights of different colors. A hopper below the center key provided controlled access to grain, and when grain was available, the hopper was illuminated with a 2-W white light. Six 2-W lights (two white, two red, two green) were mounted above the wire-mesh ceiling of the chamber. The chamber was enclosed in a sound-attenuating box containing a ventilation fan. All stimuli were controlled and responses record-

ed by an IBM®-compatible personal computer using the Medstate® programming language.

Procedure. The experiment consisted of six conditions. In all conditions, each session lasted for 64 trials or for 60 min, whichever came first. Each block of four trials consisted of two forced trials followed by two choice trials. At the start of each trial, the white houselights were lit and the center key was transilluminated with white light. A single peck on the center key was required to begin the choice period. The purpose of this center peck was to make it more likely that the subject's head was equidistant from the two side keys when the choice period began. On choice trials, a peck on the center key darkened this key and illuminated the two side keys, one key green and the other red. The positions of the two key colors were varied randomly over trials. A single peck on the green key constituted a choice of the standard alternative, and a single peck on the red key constituted a choice of the adjusting alternative.

To illustrate the general procedure, Figure 1 shows the two possible sequences of events that could occur in the final condition of this experiment (Condition 6). For both alternatives, a VT 20-s schedule was in effect for a total of 40 s each trial, but this 40 s was interrupted at some point, and a ratio requirement had to be completed before the VT schedule resumed. In Condition 6, each choice of the green (standard) key led to (a) offset of the two keylights and the white houselights, onset of the green houselights, and a 6-s segment with the VT schedule in effect; (b) offset of the green houselights and onset of the green keylight and white houselights, which remained on until the subject completed an FR 5 response requirement; and (c) offset of the green keylight and white houselights, onset of the green houselights, and a 34-s segment with the VT schedule in effect. Each choice of the red (adjusting) key led to (a) offset of the two keylights and the white houselights, onset of the red houselights, and a 20-s segment with the VT schedule in effect; (b) offset of the red houselights and onset of the red keylight and white houselights, which remained on until the subject completed an adjusting-ratio requirement; and (c) offset of the red keylight and

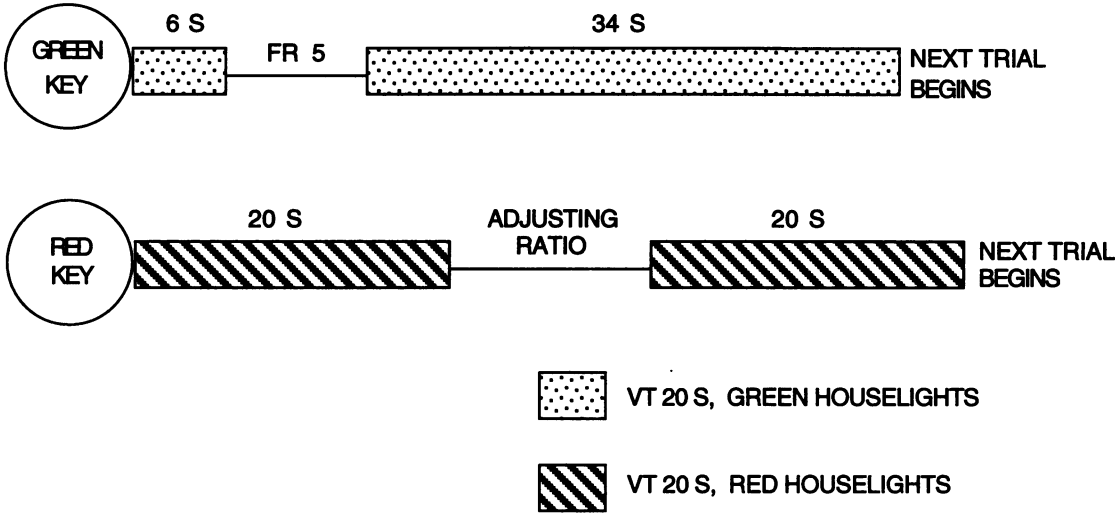


Fig. 1. The consequences of a choice of the green key and the red key are illustrated for Condition 6 of Experiment 1.

white houselights, onset of the red houselights, and a second 20-s segment with the VT schedule in effect. The size of the adjusting ratio typically increased and decreased several times a session, as explained below.

Whenever the VT schedule delivered a reinforcer, the colored houselights were extinguished, the white light in the food hopper was lit, and grain was presented for a maximum of 2 s. However, if a VT segment was scheduled to end before the 2-s reinforcement period was over, the reinforcement period was shortened accordingly, to keep the durations of the VT segments exactly as scheduled.

The procedure on forced trials was the same as on choice trials, except that only one

side key was lit, red or green, and a peck on this key led to the sequence described above. A peck on the opposite key, which was dark, had no effect. Of every two forced trials, one involved the red key and the other the green key. The temporal order of these two types of trials varied randomly.

After every two choice trials, the adjusting ratio might be changed. If a subject chose the adjusting key on both choice trials, the adjusting ratio was increased by one response (up to a maximum of 35 responses). If the subject chose the standard key on both trials, the adjusting ratio was decreased by one response (down to a minimum of one response). If the subject chose each key on one trial, no change was made in the adjusting ratio. In all three cases, this adjusting ratio remained in effect for the next block of four trials. In the first session of each condition, the adjusting-ratio requirement began at one response. At the start of later sessions of the same condition, the adjusting ratio was determined by the above rules as if it were a continuation of the preceding session.

In all conditions, an FR 5 schedule was in effect for the standard alternative, and the adjusting-ratio schedule was in effect for the adjusting alternative. The only changes across conditions were the durations of the two VT segments for each alternative. Table 1 presents these durations for each condition. In

Table 1
Durations of the VT segments (in seconds) for each condition of Experiment 1.

	Standard (green) alternative		Adjusting (red) alternative	
	VT	VT	VT	VT
Condition Segment 1	Segment 2	Segment 1	Segment 2	
1	2	38	2	38
2	2	38	20	20
3	2	38	6	34
4	2	38	12	28
5	6	34	6	34
6	6	34	20	20

Conditions 1 through 4, the first VT segment for the standard alternative lasted for only 2 s, and the second VT segment lasted for 38 s. The first VT segment for the adjusting alternative ranged from 2 s to 20 s in these conditions. In Conditions 5 and 6, the duration of the first VT segment was increased to 6 s, and the first VT segment for the adjusting alternative was either 6 s or 20 s. In all conditions, the durations of the two VT segments totaled 40 s for both alternatives.

Most conditions lasted for a minimum of 20 sessions, but Condition 5, which featured a change in the duration of the first VT segment for the standard alternative, lasted for a minimum of 30 sessions. After the minimum number of sessions, a condition was terminated for each subject individually when several stability criteria were met. To assess stability, each session was divided into two 32-trial blocks, and for each block the mean ratio on the adjusting key was calculated. The results from the first two sessions of a condition were not used, and the condition was terminated when all of the following criteria were met, using the data from all subsequent sessions: (a) Neither the highest nor the lowest single-block mean of a condition could occur in the last six blocks of a condition. (b) The mean adjusting ratio across the last six blocks could not be the highest or the lowest six-block mean of the condition. (c) The mean ratio of the last six blocks could not differ from the mean of the preceding six blocks by more than 10% or by more than one response (whichever was larger).

Results

The number of sessions required to satisfy the stability criteria ranged from 21 to 44 (median, 25.5 sessions). For each condition, the results from the six half-session blocks that satisfied the stability criteria were used for all data analyses. For each subject, the mean adjusting ratio from these blocks was treated as a measure of the indifference point—a ratio at which the two alternatives were chosen about equally often. Figure 2 shows the mean adjusting ratios for each subject and each condition. Although there were some exceptions, the general trend in the results is clear: As the delay to the onset of the adjusting ratio increased from 2 s to 20 s, the mean adjusting ratio tended to increase as

well. When the delay to the adjusting ratio was 2 s, the mean adjusting ratio was less than 10 responses for all subjects. When the delay to the adjusting ratio was 20 s, the mean adjusting ratio was greater than 30 responses (and thus close to the maximum of 35 responses) in six of eight cases. A repeated measures analysis of variance (ANOVA) revealed a significant effect of condition, $F(5, 15) = 6.61$, $p < .01$. A planned comparison conducted with the results from the first four conditions (those with a 2-s delay to the standard ratio) revealed a significant linear trend in the mean adjusting ratios as the delay to the adjusting ratio increased, $F(1, 15) = 25.41$, $p < .01$. There was also a significant difference between Conditions 5 and 6 (the two conditions with a 6-s delay to the standard ratio), $t(3) = 3.71$, $p < .05$.

Not surprisingly, the amount of time subjects took to complete the adjusting ratio increased as the ratio size increased. Harmonic means of each subject's ratio completion times were calculated for the standard and adjusting-ratio schedules for each condition. Harmonic means were used to minimize the impact of occasional very long ratio completion times that occurred when subjects paused before the ratio was completed. For the standard alternative, the mean time to complete the FR 5 schedule was 3.9 s. Ratio completion times for the adjusting key ranged from a mean of 4.2 s for the five cases with a mean adjusting ratio of less than 10 responses to 46.0 s for the 10 cases with a mean adjusting ratio of more than 30 responses. Therefore, when the adjusting ratio was large, the duration of a trial was substantially longer for the adjusting key, as was the time from a choice response to the start of the second VT segment.

Although Figure 2 shows a large overall increase in the mean adjusting ratio with increases in the delay to the start of this ratio, several inconsistencies in the results are also apparent. First, there were reversals in the generally increasing functions for 2 subjects. Second, in some conditions, there was considerable intersubject variability in the mean adjusting delays. Third, there were no systematic differences between the mean adjusting ratios from the first four conditions and those from the last two conditions. Assuming that the delay to the onset of the ratio require-

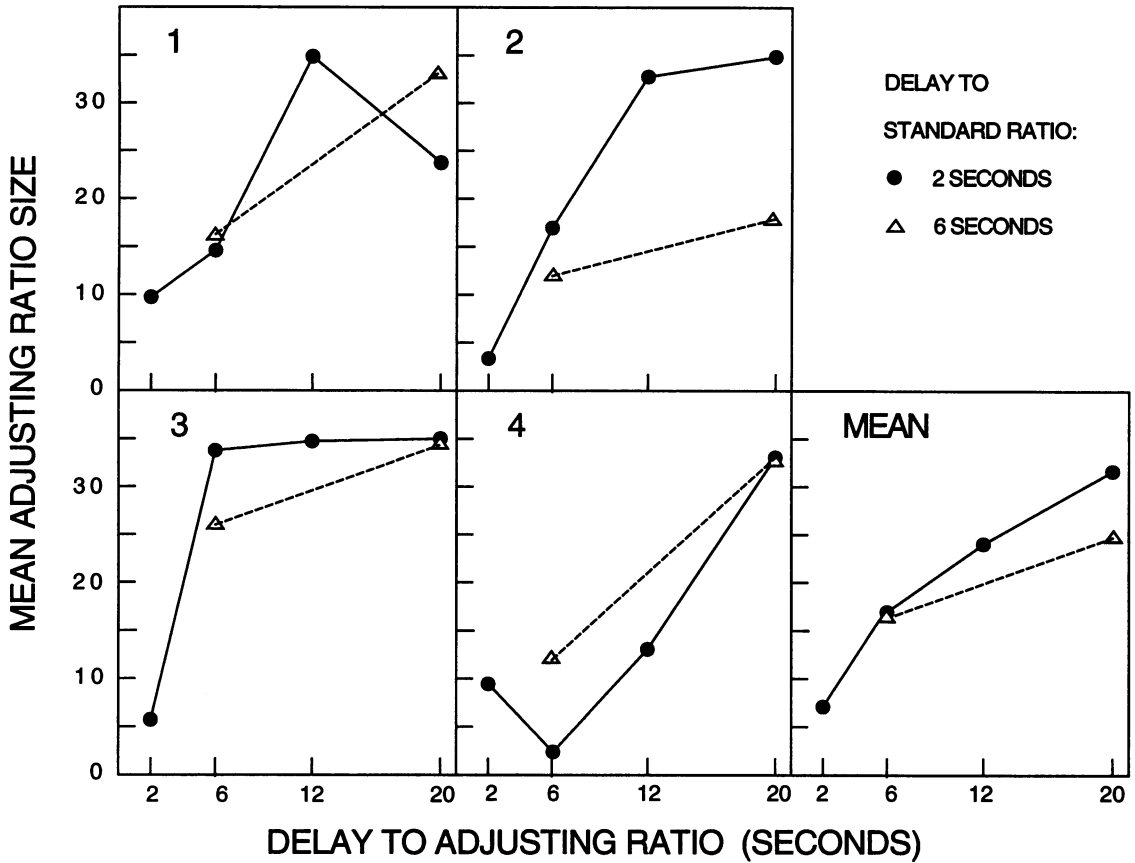


Fig. 2. Mean adjusting-ratio sizes (indifference points) are shown for each subject and each condition of Experiment 1. The results are plotted as a function of the delay to the start of the adjusting ratio. The circles are the results from the first four conditions, which had a 2-s delay to the start of the standard ratio. The triangles are the results from the last two conditions, which had a 6-s delay to the start of the standard ratio.

ment is an important factor for both alternatives, preference for the standard alternative should have increased in the last two conditions, because the delay to the standard ratio was 6 s. With the adjusting-ratio procedure, an increase in preference for the standard alternative would appear as a smaller mean adjusting ratio. Only Subject 2 showed a large effect of this type. Some possible reasons for these inconsistencies are considered in the Discussion section.

Discussion

This study found that as the time to the onset of the adjusting ratio increased, the mean adjusting ratios increased as well. Although there was some variability and inconsistency in the results, the increases in the adjusting ratios were statistically significant and

large in size, ranging from a mean of 7.0 responses in Condition 1 to a mean of 33.2 responses in Condition 2. These results suggest not only that a procrastination effect can be found with pigeons but that the effect is a large one. For example, the results from Condition 2 showed that, on average, subjects were just as likely to choose a 33-response requirement that was delayed 20 s as a five-response requirement that was delayed only 2 s. In addition, the indifference points obtained in this experiment probably underestimate the actual size of the procrastination effect, for two reasons. First, the obtained indifference points may be limited by a ceiling effect, because the maximum possible adjusting ratio was 35 responses, and the results from several conditions were close to this maximum. Second, whenever the adjusting

ratio was larger than the standard FR 5, subjects took more time to complete the adjusting ratio, which meant that the start of the second VT segment was more delayed. In other words, in most conditions each choice of the adjusting alternative involved two disadvantages: The adjusting ratio was larger than the standard ratio, and the second VT segment started later.

The indifference points in Figure 1 exhibit more variability within and across subjects than has been found in previous studies using either a similar adjusting-ratio procedure (Grossbard & Mazur, 1986; Mazur & Kralik, 1990) or an adjusting-delay procedure (e.g., Mazur, 1984, 1987, 1988). In some instances, inconsistencies in the present data may have resulted from hysteresis, in which behavior in one condition is influenced by the contingencies of previous conditions. For example, the mean adjusting ratios in the two conditions with a 6-s delay to the adjusting ratio were similar, although the delay to the start of the standard ratio was different in the two conditions. This could reflect a failure to respond to the change to a 6-s delay to the standard ratio in Condition 5 after four consecutive conditions in which the delay was 2 s. A second reason for the inconsistencies in the data might have been the fairly complex contingencies that were used in this experiment. In previous studies with the adjusting-ratio procedure, each condition generally included just two different ratio schedules and two different reinforcer amounts. In contrast, each condition of the present experiment included four separate VT segments, usually of different durations, and two different ratio schedules, one of which changed over trials. In different VT segments, there could be zero, one, or more than one food presentation, which occurred at random times. The presence of all of these variables may have made it more difficult for the subjects to discriminate the contingencies and develop a consistent pattern of choices.

These results have been presented as evidence for procrastination—the choice of a larger, more delayed response requirement. However, two other possible explanations of why subjects chose the adjusting alternative so frequently should be considered. First, notice that in the first four conditions, the first VT segment was only 2 s for the standard al-

ternative. A food presentation was unlikely to occur in this time, and if it did, it would usually be a brief presentation, because it would end at the 2-s mark no matter when it began. Therefore, in these conditions, the subject's main opportunities to obtain food from the standard alternative began only after the ratio requirement was completed. With the adjusting alternative, however, the first VT segment was longer in most conditions, so food presentations were much more likely to occur in this segment. Thus, one could argue that subjects chose the adjusting alternative because it offered a good chance of obtaining a reinforcer before the response requirement, whereas the standard alternative did not. However, this argument is less convincing for Conditions 5 and 6, in which the first VT segment was 6 s for the standard alternative and the chances of a food presentation in this segment were greater.

A related but slightly different account of the results is based on the concept of timeout from positive reinforcement. Because each ratio schedule interrupted a VT schedule that was present throughout the rest of each trial, these ratio schedules could be treated as timeouts from positive reinforcement. Previous studies have shown that avoiding a timeout from positive reinforcement can serve as an effective reinforcer for pigeons (Galbicka & Branch, 1983; Hackenberg, 1992). Perhaps the requirement to perform the key-peck responses was irrelevant, and subjects were simply choosing between smaller, more immediate timeouts and larger, more delayed timeouts. This could also be considered a type of procrastination, but one in which subjects avoided a small, proximal timeout at the expense of a longer, later timeout.

Although the procedure used in Experiment 1 cannot distinguish between these alternative explanations, other procedures can. The following two experiments eliminated both the chance of obtaining an immediate reinforcer and the possibility that the ratio schedules were serving as timeouts from positive reinforcement.

EXPERIMENT 2

This short experiment was conducted to determine whether a procrastination effect could be obtained if no reinforcers were de-

livered before or immediately after the ratio schedules. In place of the VT schedules of Experiment 1, Experiment 2 used delays without reinforcers before and after the ratio schedules. The only reinforcer was a 4-s food presentation at the end of each trial. No adjusting ratio was used in this experiment: The response requirement was always FR 8 for both alternatives. However, the delay between a choice response and the onset of the ratio requirement was longer for one alternative than for the other. Procrastination would be exhibited if subjects showed a preference for the alternative with the longer delay to the onset of the FR 8 schedule.

Method

Subjects and apparatus. The subjects were the same as those in Experiment 1. The same apparatus was used, except that the green and red keylights and houselights were replaced by orange and blue keylights and houselights.

Procedure. Each session lasted for 64 trials or for 60 min, whichever came first. The general procedure was similar to that of Experiment 1: Each block of four trials consisted of two forced trials followed by two choice trials. Each trial began with the illumination of the white center key, and a single peck on this key led to the choice period, in which one side key was orange and the other blue (except that only one side key was lit on forced trials). In Condition 1, a peck on the orange key led to the following sequence of events: a 2-s delay with orange houselights, an FR 8 response requirement with the orange key and white houselights lit, a 15-s delay with orange houselights, then a 4-s reinforcer. A peck on the blue key led to the following sequence of events: a 15-s delay with blue houselights, an FR 8 response requirement with the blue key and white houselights lit, a 2-s delay with blue houselights, then a 4-s reinforcer. A 20-s intertrial interval (ITI) with white houselights followed each trial. Condition 2 was a reversal condition in which the durations of the delays for the two key colors were switched: The delays for the orange key were now 15 s before the FR requirement and 2 s after, and the opposite was true for the blue key.

Each condition was scheduled to remain in effect for a minimum of 20 sessions, and until

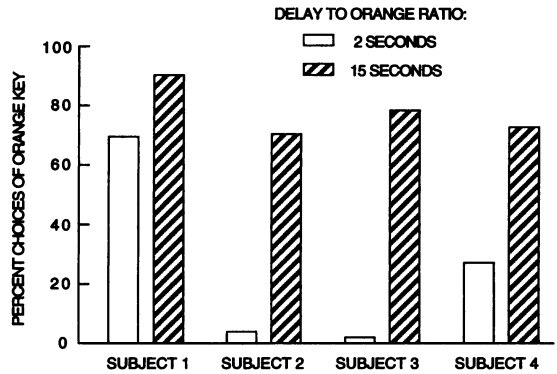


Fig. 3. Percentages of choices of the orange key are shown for each subject in the two conditions of Experiment 2. The results are from the last five sessions of each condition.

a subject's percentage of choice responses on the orange key in each of the last five sessions was not the highest or lowest percentage of the condition. As it turned out, this criterion was met in the minimum 20 sessions by all subjects in each condition.

Results and Discussion

All analyses were based on the last five sessions of each condition. Figure 3 shows the percentage of choice responses made on the orange key in each condition. For all 4 subjects, the percentage of orange-key choices was substantially higher when the delay to the FR requirement was longer than that for the blue key. Subject 1 chose the orange key on more than 50% of the trials in both conditions, possibly showing a color bias, but its choice percentages still differed in the expected direction. For the group, the mean orange-key choice percentage was 25% in Condition 1 and 78% in Condition 2. The difference between conditions was statistically significant, $t(3) = 4.20$, $p < .05$.

Harmonic means of each subject's ratio completion times were calculated for the two alternatives in each condition. For all 4 subjects in both conditions, the mean ratio completion time was greater for the alternative with the 2-s initial delay. For the group, the mean ratio completion time was 6.9 s when the ratio followed a 2-s delay and 4.2 s when the ratio followed a 15-s delay. A simple explanation of this difference is that subjects completed the FR 8 requirement faster when

it was followed by a shorter delay to reinforcement (2 s rather than 15 s).

These results suggest that the procrastination effect is not limited to situations in which a response requirement serves as a timeout from positive reinforcement. Subjects showed a strong preference for the alternative that had a longer delay to the start of the ratio schedule, even though the schedule was FR 8 for both alternatives, and the total delay time (combining the delays before and after the ratio schedule) was 17 s for both alternatives. The only procedural difference between the two alternatives was the temporal placement of the ratio requirement, and this apparently had a large effect on the subject's choices. However, one other possible explanation of these results is that subjects chose the alternative on which they had shorter ratio completion times, because for this alternative the actual times between a choice response and food were shorter. This possibility seems unlikely because the actual total times to reinforcement were quite similar for the two alternatives (averaging 23.9 s when the first delay was 2 s and 21.2 s when the first delay was 15 s). In any case, this possible explanation was ruled out in Experiment 3.

EXPERIMENT 3

The procedure of this experiment was similar to that of Experiment 2: Delays without reinforcers occurred both before and after a ratio requirement, and one reinforcer was delivered at the end of each trial. However, the adjusting-ratio procedure used in Experiment 1 was reintroduced. The schedule for the standard alternative was FR 8, and the delay to the start of the adjusting ratio was varied across conditions. If subjects were to procrastinate (to choose the response requirement that began later), the results should resemble those of Experiment 1 (see Figure 2): The adjusting ratio at the indifference point should become progressively larger as the delay to the start of the adjusting ratio is increased.

Method

Subjects and apparatus. The subjects were the same as those in Experiment 2, and the same apparatus was used.

Procedure. Each session lasted for 64 trials

Table 2

Durations of the delays (in seconds) for each condition of Experiment 3.

Condition	Standard (orange) alternative		Adjusting (blue) alternative	
	Delay 1	Delay 2	Delay 1	Delay 2
1	15	2	2	15
2	2	15	15	2
3	2	15	5	12
4	2	15	2	15
5	2	15	15	2

or 60 min, whichever came first. Blocks of four trials consisted of two forced trials followed by two choice trials. The general procedure was similar to that of Experiment 2: Subjects chose between orange and blue keys, and each alternative consisted of a delay, a ratio requirement, a second delay, and then a 3-s reinforcer. A 20-s ITI followed each trial. The main difference from Experiment 2 was that the adjusting-ratio procedure was employed. The orange key was the standard key, and the ratio requirement for this key was FR 8 throughout the experiment. The blue key was the adjusting key, and the size of the ratio was adjusted over trials by the same rules as in Experiment 1.

Table 2 shows the durations of the delays before and after the ratio schedules for both alternatives in the five conditions of this experiment. In all conditions, the durations of the two delays summed to 17 s for each alternative. In Condition 1, the first delay was 15 s for the standard alternative and 2 s for the adjusting alternative. In the remaining four conditions, the first delay was 2 s for the standard alternative, and ranged from 2 s to 15 s for the adjusting alternative. The delays in Conditions 2 and 5 were identical. Each condition lasted for a minimum of 20 sessions, and was terminated individually for each subject according to the same stability criteria used in Experiment 1.

Results and Discussion

The number of sessions required to satisfy the stability criteria ranged from 20 to 45 (median, 23 sessions). For each condition, the results from the six half-session blocks that satisfied the stability criteria were used for all data analyses. For each subject, the mean adjusting ratio from these blocks was

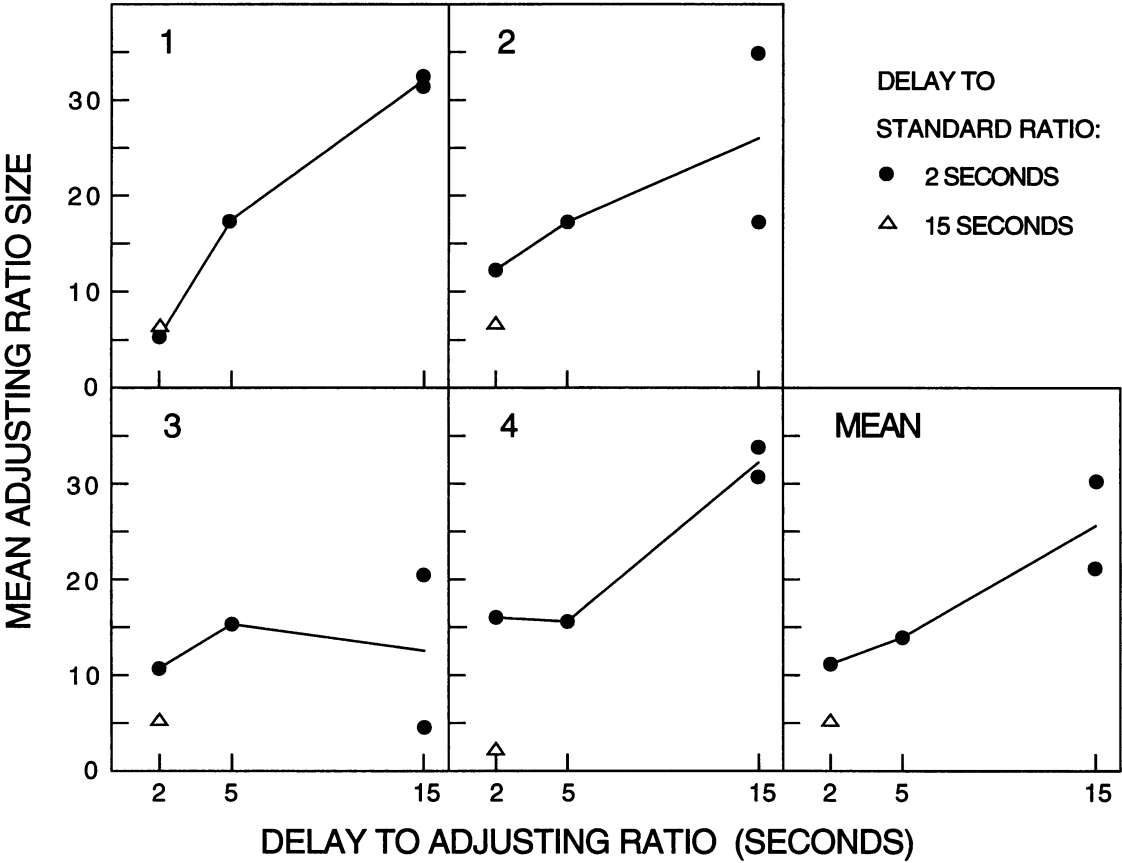


Fig. 4. Mean adjusting-ratio sizes (indifference points) are shown for each subject and each condition of Experiment 3. The filled circles are the results from the last four conditions, which had a 2-s delay to the start of the standard ratio. For the conditions with a 15-s delay (Conditions 2 and 5), both data points are plotted, and the lines show the means of these two conditions. The triangles are the results from Condition 1, which had a 15-s delay to the standard ratio and a 2-s delay to the adjusting ratio.

treated as a measure of the indifference point. Figure 4 shows the mean adjusting ratios for each subject and each condition. Except for Subject 3, the mean adjusting-ratio size tended to increase as the delay to the start of this ratio increased, which can be described as procrastination. The inconsistent results for Subject 3 were mainly due to Condition 2, which had an indifference point of 4.5 responses (the lower point with a 15-s delay in Figure 4). When the same delays were repeated in Condition 5, the indifference point for this subject was 20.5 responses. One possible explanation is that Subject 3 was slow to respond to the change from Condition 1 to Condition 2, in which the delays for the two alternatives were switched. Subject 2 exhibited a similar difference in the results

from Conditions 2 and 5, except that the indifference point from Condition 2 was still slightly larger than that with shorter delays. Despite these exceptions, the mean results in Figure 4 show the predicted increasing pattern, and this trend was statistically significant. A repeated measures ANOVA revealed a significant effect of condition, $F(4, 12) = 8.12, p < .01$. A planned comparison conducted with the results from the last four conditions (those with a 2-s delay to the standard ratio) revealed a significant linear trend in the mean adjusting ratios as the delay to the adjusting ratio increased, $F(1, 12) = 12.10, p < .01$.

In Condition 1, the delay to the standard ratio was longer than the delay to the adjusting ratio, which would presumably lead to a

preference for the adjusting ratio. Such a preference would be seen as a mean adjusting ratio less than eight responses, because the standard ratio was FR 8. The mean adjusting ratios were less than eight responses for all subjects, averaging 5.2 responses for the group.

Taken as a whole, the results of this experiment are consistent with the prediction that at the indifference point, subjects will accept a larger ratio requirement for whichever alternative has a longer delay to the start of this ratio. Unlike Experiment 2, this experiment ruled out the possibility that preference for the more delayed ratio requirement might be caused by a shorter total delay to food, because (as expected) subjects usually took longer to complete the larger ratios. Harmonic means of each subject's ratio completion times were calculated for the standard and adjusting-ratio schedules for each condition. For the standard alternative, the mean time to complete the FR 8 schedule was 5.4 s. Ratio completion times for the adjusting key ranged from a mean of 3.4 s for the seven cases with a mean adjusting ratio of less than 10 responses to 17.6 s for the six cases with a mean adjusting ratio of more than 30 responses. Thus, there were two disadvantages to a choice of the alternative with the longer delay to the start of the ratio requirement: (a) The ratio requirement was larger, and (b) the total time to the food delivery was longer. These results therefore fit the definition of procrastination as it has been used throughout this article—a preference for a larger but more delayed work requirement.

As another interpretation of Experiments 2 and 3, we should consider the possibility that the temporal segmentation of the two choice alternatives was a critical factor. Leung and Winton (1985, 1986) reported that pigeons preferred unsegmented intervals (e.g., a simple fixed-interval [FI] 30-s schedule) over equally long segmented intervals (e.g., a chained FI 15-s FI 15-s schedule, in which the transition from the first FI to the second was accompanied by a change in discriminative stimuli). More important, Leung and Winton (1988) found that the segmented intervals were least preferred when the first segment was short (e.g., chained FI 2 s FI 28 s). Extrapolating from these findings, it could be argued that the response requirements in Ex-

periments 2 and 3 were irrelevant, and that subjects were simply avoiding the alternative that had the shorter first segment (the earlier change from colored houselights to a colored keylight). Although this possibility cannot be ruled out without further experimentation, it seems unlikely that the large and systematic variations in the adjusting ratio were merely due to a change in stimuli and not to the response requirements, especially because Leung (1987) found that unsegmented intervals were preferred in part because they involved fewer response requirements. In fact, some of the effects observed by Leung and Winton may have actually been additional cases of procrastination. Notice that in a single FI 30-s schedule, no responses are required in the early part of the interval, and there is typically a pause in responding. However, in a chained FI 2-s FI 28-s schedule, an early response is required to advance to the second FI schedule. It is therefore possible that preference was lowest for the chained schedules with short initial FIs because these chains required additional responding soon after they began.

GENERAL DISCUSSION

The results from each of these three experiments provided statistically significant evidence for procrastination, using three somewhat different experimental designs. Besides being statistically significant, the procrastination effects were also large in size, as measured by changes in the adjusting ratio at the indifference points. It is also important to note that they were replicable both within and between subjects. For example, in Experiment 3, the mean adjusting ratio was 11 when the delay to the start of the ratio was 2 s, but the ratio was 30 when the delay was increased to 15 s. Both of these indifference point estimates were obtained with the same standard alternative (an FR 8 schedule beginning 2 s after the choice response), so they indicate that the subjects accepted a three-fold increase in the adjusting ratio when its onset was delayed by an additional 13 s. Equally large variations in the adjusting ratio across conditions were found in Experiment 1.

Although the effects were robust in these studies, the indifference points were less consistent within and across subjects than those

obtained with similar adjusting-ratio or adjusting-delay procedures and positive reinforcers (e.g., Grossbard & Mazur, 1986; Mazur, 1987; Rodriguez & Logue, 1988). The reasons for this greater variability in the data are not clear.

It might seem surprising that pigeons would choose an alternative with a much larger ratio requirement when the only advantage was that the start of that ratio was delayed by a few extra seconds. However, these results are quite consistent with those from self-control choice situations involving positive reinforcers, in which pigeons frequently choose a reinforcer that is three times smaller than its alternative, when the only advantage is that its onset is a few seconds sooner (e.g., Green, Fisher, Perlow, & Sherman, 1981; Rachlin & Green, 1972; Rodriguez & Logue, 1988). The results are also consistent with studies on choice between immediate and delayed shocks (e.g., Deluty, 1978; Deluty et al., 1983). The same general conclusion can be drawn from all of these choice situations: As the delay between a choice response and the onset of an event (either positive or negative) increases, the impact of that event on the choice response declines dramatically. The consequences of longer delays are symmetrical but opposite for reinforcers on the one hand and aversive events and response requirements on the other: Subjects become less likely to choose a larger reinforcer as its delay increases, but they become more likely to choose a larger aversive event or response requirement as its delay increases.

If the effects of delay are indeed similar for reinforcers and aversive events, perhaps the same mathematical function can be applied to both. In several experiments with positive reinforcers, I have found that a reinforcer's value (its ability to sustain choice responses) can be well described by a hyperbolic equation, $V = A/(1 + KD)$, where V is the reinforcer's value, A represents the reinforcer's amount, D is its delay, and K is a free parameter (e.g., Mazur, 1984, 1987, 1993). This equation could be adapted for choices involving aversive events by allowing A to represent the size of an aversive event and V the negative value of the event. The large increases in the adjusting ratios in Figures 2 and 4 are at least roughly consistent with the view that the aversiveness of a response requirement declines

steadily with increasing delay. However, these experiments were not specifically designed to test the hyperbolic decay model, and a larger and more systematic data set is needed to determine whether the model can be applied to response requirements as hedonically negative events. For now, we can at least conclude that the effects of delayed response requirements and delayed reinforcers are similar at a qualitative level: In both cases, there is an inverse relationship between the event's delay and its influence on choice behavior.

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